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12th International Conference on Materials Chemistry

Highlights of materials chemistry research

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Materials chemistry is concerned with establishing connections between structure, properties, processability and performance of molecular materials, including organic compounds and polymers, supramolecular architectures and nanoporous substances. Encompassed within this diverse field are molecular magnets, graphene, optoelectronic devices, artificial photosynthesis, chemical sensors, speciality polymers, fluorescent labels, functional membranes, composite conjugated hybrids and molecular sieves. The field relies heavily on sophisticated organic synthesis but readily embraces computational chemistry in order to delve more deeply into the properties of the materials. The topic provides an important interface between atomic, molecular and supramolecular behaviour and the functions of the substance under examination. All manner of molecular materials are considered, ranging from thin films to organogels to solids with microscopic cavities. The 12th International Conference on Materials Chemistry was held between 20th–23rd July 2015 at the University of York, UK, and covered the full range of topics, with six plenary lectures supported by twenty-four keynote lectures and over a hundred invited or contributed talks (1). In addition, some 370 posters were presented. The conference was co-chaired by Duncan Bruce (University of York) and Dermot O'Hare (University of Oxford, UK).

Platinum Group Metals

Materials chemistry relies heavily on the synthesis of new molecular building blocks, mostly organic or organometallic compounds equipped with particular functions. A vast array of such substances was reported during the conference, a large fraction of which required the use of platinum, palladium or rhodium catalysts for the key assemblage steps. Most notably, homogeneous Pd catalysts underpinned the construction of new molecular architectures based on Heck or Suzuki reactions, Negishi or Sonogashira coupling, Stille reactions or Buchwald-Hartwig amination. Cyclisation reactions, catalysed by Pt and utilising new alkyne derivatives, provided easy access to routes to a plethora of novel structures possessing advanced properties. In addition, ruthenium and iridium complexes were used extensively to generate triplet emitters and/or photocatalysts. In sessions covering progress in artificial photosynthesis, Pt- and Ru-based reagents proved to be the most effective catalysts for H_2 and O_2 liberation from water. A common theme running throughout the conference was that, while the properties and functions of the new materials were described in detail, the essential chemistry leading to their synthesis remained in the background. Thus, the

platinum group metals (pgms) were less prominent than would be have been the case if the main focus had concerned synthesis.

Even so, the pgms made numerous key contributions to the conference. Among the many excellent presentations, we draw attention to the newly developed Pt- and Ir-containing multimetallic triplet emitters reported by Gareth Williams *et al*. (Durham University, UK). These compounds are based on cyclometallated Ir(III) and Pt(II) complexes and important differences in the recorded photophysical properties are noted between mononuclear and multinuclear species (**Figure 1**). Such materials have applications in organic light-emitting diodes (OLED) and bioimaging. Somewhat related multiple chromophoric assemblies were reported by Anthony Harriman and Raymond Ziessel (Newcastle University, UK), with the main emphasis being placed on the development of artificial light-harvesting arrays (**Figure 2**). The use of Ru(II) complexes as photosensitisers for the visible light induced oxidation of water was reported by Dominic Walsh *et al*. (University of Bath, UK). In this latter study, the oxygen-evolving catalysts were formed from manganese dioxide (MnO_2) and cobalt oxide (CoO_x). High rates of water oxidation were described by Richard Walton (University of Warwick, UK) using novel forms of ruthenium(IV) oxide (RuO_2) and iridium(IV) oxide (IrO_2).

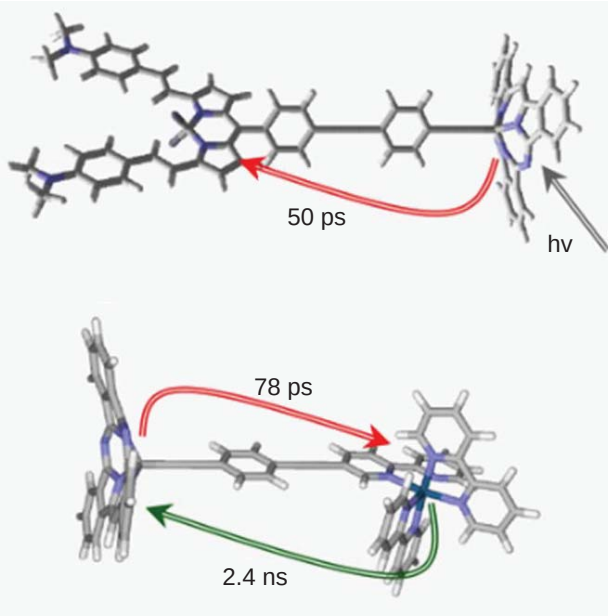

Fig. 2. Typical light-harvesting systems reported by Harriman and Ziessel. The upper panel shows fast electronic energy transfer following selective illumination of a sub-phthalocyanine dye (energy donor) appended to an expanded boron dipyrromethene dye (acceptor). The lower panel shows that replacing the latter acceptor with an osmium(II) tris(2,2-bipyridine) complex serves to convert the excited-singlet state to a triplet emitter. The time scales refer to the relevant energy transfer steps (Reproduced by permission of The Royal Society of Chemistry)

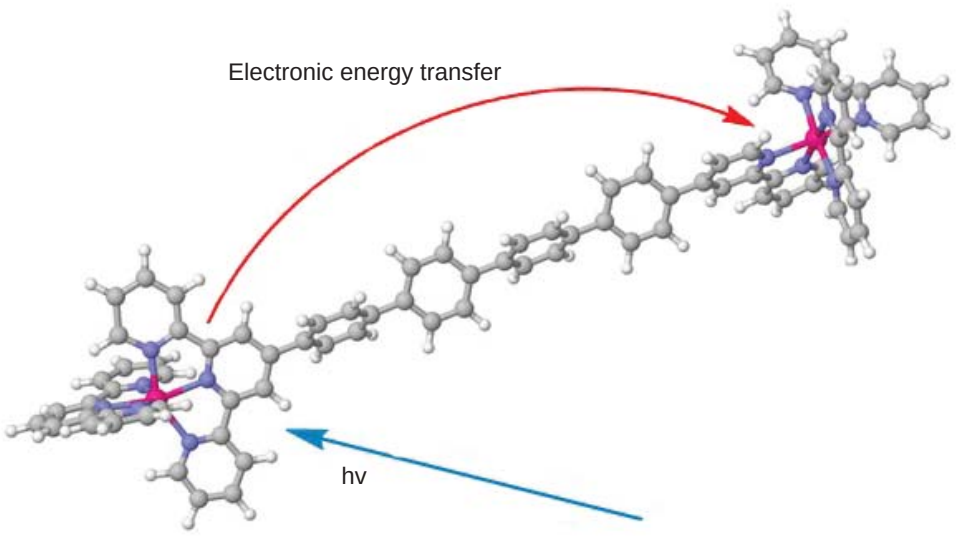

Fig. 1. Example of the polymetallic Ir/Ru complexes used by Gareth Williams *et al*. to study intramolecular triplet energy transfer

These catalysts were employed in the form of mixed-metal pyrochlores and have possible applications in water electrolysers. Photochemical water oxidation was reported by Borbala Kiss *et al*. (University of Liverpool, UK) The active substrate was formed by Rh substitution into the yttrium titanate ($Y_2Ti_2O_7$) pyrochlore and it was noted that oxygen evolution rivalled that observed from tungsten trioxide (WO_3) but with much improved light harvesting capability. Despite the enormous effort expended on the search for new oxygen-evolving catalysts, it is clear that the optimum performance is derived from RuO_2 and IrO_2 based materials.

Interesting results were reported by Richard Baker *et al.* (University of St Andrews, UK) regarding the preparation of Pd-based catalysts for methanol reforming. Here, the support was a high surface area, nanostructured ceria while the adsorbate was Pd or PdO. In certain cases, samarium was also doped into the ceria support. These materials appear to exhibit impressive performance for both methane combustion and alcohol reforming under relatively mild conditions. The synthesis of Pt-functionalised tin dioxide (SnO_2) sheets for propan-2-ol gas detection was described by Igor Djerdj (Rudjer Boskovic Institute, Croatia).

Soft Materials

Photoresponsive soft matter materials were described by Yann Molard *et al*. (University of Rennes 1, France) and by Etienne Borré *et al*. (University of Strasbourg, France). Such materials, especially when engineered in the form of organogels, could have important applications in luminescence-based technologies. Incorporating the pgms into these soft materials is not a straightforward procedure but could lead to novel matrices with useful optoelectronic applications. Likewise, Pt(II) and Pd(II) ions can be used to assemble metallo-supramolecular structures with interesting optical properties. Used in the form of a gel, these compounds give rise to stimuli-responsive systems with sensing properties. In fact, this is a particularly active research field, fuelled by the recognition that the key features of organogels have not been adequately exploited to date. The presence of certain pgms switches on the possibility for luminescence sensing, such as the *in situ* detection of molecular oxygen. Extension of Pt(II)-based ensembles into polymeric matrices was considered by Kevin Chan *et al*. (The University of Hong Kong, China), with particular reference to electronic energy transfer processes. The photophysical properties of such Pt(II) polyynes can be modulated by incorporating an azobenzene spacer into the conjugated ligand, as illustrated by Raya Al-Balushi and Muhammad Khan (Sultan Qaboos University, Oman). When substituted with fullerenes, these materials could provide improved performance of organic photocells. Replacing Pt(II) with Ir(III) leads to marked changes in the luminescence properties, as described by Ruth Daniels *et al.* (Northumbria University, UK), while mixed Pt(II)-Ir(III) complexes favour intramolecular triplet energy transfer.

Photochemical Dissociation of Water

The possible generation of a useful fuel *via* the photochemical dissociation of water continues to attract attention. One of the tried-and-tested methodologies for H_2 generation involves the ultraviolet (UV)-photolysis of titanium dioxide (TiO_2) coated with deposits of Pt. This system has been around for more than four decades but new results were presented by Greta Haselmann *et al*. (University of Münster, Germany). Here, the Pt deposit plays the key role of catalyst for proton reduction (**Figure 3**). Related work was presented by Michael Nolan, Alexander Cowan and Dave Adams (University of Liverpool) and concerned the replacement of the TiO_2 semiconductor with photoconductive perylene bisimide gelators.

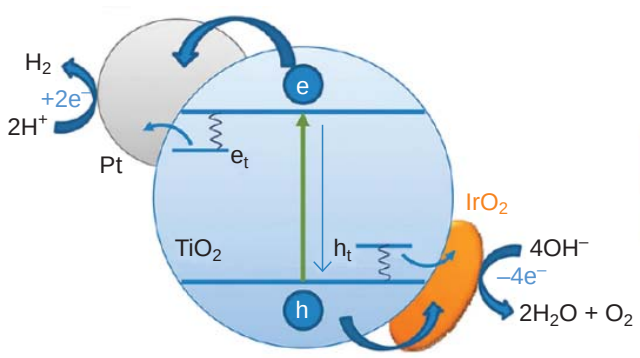

Fig. 3. Typical colloidal particle proposed for photochemical dissociation of water into hydrogen and oxygen. UV-illumination of a titania particle leads to separation of conduction-band electrons and surface-bound positive holes. The electrons move towards a Pt-based reduction catalyst while the positive holes accumulate at an IrO_2-based anode (Reprinted with permission from (2). Copyright (2012) American Chemical Society)

Conclusion

Overall, the meeting was a huge success. The venue was excellent, access to lecture rooms was easy, and the large number of delegates catered for in a relaxed but competent manner. Poster sessions were well organised and disciplined. The plenary lectures were outstanding.

References

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The Reviewer

Anthony Harriman started his career in artificial photosynthesis at the Royal Institution in London, UK, in 1974, working under Sir George Porter. He spent a total of 14 years at the Royal Institution, including terms as Dewar Research Fellow, 1977–1988, and Assistant Director of the Davy-Faraday Research Laboratory, 1982–1988. He moved to the University of Texas at Austin, USA, in 1988 to become Director of the Center for Fast Kinetics Research. This was followed by a short stay at the Université Louis Pasteur in Strasbourg, France. In 1999, he took up the position of Professor of Physical Chemistry at Newcastle University, UK. He has maintained a strong interest in artificial photosynthesis. Among his many awards are the Corday-Morgan Medal and Prize, 1984, the first Prix Grammaticakis-Neumann en Photochimie, 1985, and the RSC Chemical Dynamics Award, 2011. He has published more than 400 papers in the areas of molecular photophysics, artificial photosynthesis and electron/energy transfer.